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SILOS

By A. D. Wilson, Division of Agricultural Extension

A silo is now recognized as an important part of the equipment of an up-to-date stock farm. It is no longer an experiment; silos have been used for more than thirty years in this country. Nearly every farmer who has used a silo is a strong advocate of its use, which is one of the best recommendations that it can have. One needs but to visit ten or a dozen farmers who have silos, and ask them concerning their experiences, to become thoroly convinced that a silo is an exceedingly valuable addition to a farm where twenty or more head of cattle are kept, and where corn is produced.

SILO HAS MANY ADVANTAGES

When corn is cut at the proper stage and put into a good silo the whole plant is eaten. There is no other practical way of storing corn and keeping it in such form that it can all be made use of. Silage is more convenient to feed than bundle-corn or almost any other rough feed commonly used on the farm. In the silo a large quantity of feed is stored in a small space, usually in a convenient place for feeding; and, being under cover, it is where it can be reached without difficulty and fed without waste, regardless of weather conditions.

Good silage is recognized as an excellent form of feed. It not only provides for the use of the whole plant, but is both palatable and succulent, two important factors in feeding when most of the feed is in dry form, as is the case in winter. All classes of animals relish silage, even hogs and poultry. As feed for either dairy or beef cattle, growing animals, or fattening stock, it is excellent. By the use of a silo it is possible to save corn that might otherwise very largely be wasted because of immaturity. By no means is the best silage made from immature corn, but when corn has been hit by frost or is likely to be, while still green, it may be very satisfactorily saved in a silo.

All animals need some sort of succulent feed. The addition of succulent feed to a ration made up largely of dry feed not only adds to the palatability, but aids in digesting the dry feed eaten. This makes silage of greater value as a feed than is indicated by its chemical composition.

One of the most important advantages of the silo is that it furnishes an almost sure supply of feed. There is no surer crop in Minnesota or the Northwest than corn. The growth of the corn crop is more largely within the control of the farmer than any other forage or feed crop produced on the farm. Drought, which always affects pastures and the hay crop, is very seldom severe enough materially to injure a corn crop that is well cared for.

In keeping livestock, it is exceedingly important that a permanent supply of feed of good quality be assured. The silo provides not only excellent feed for winter but also a means of keeping over feed of high quality for summer use. If the pastures are injured by drought, or are not sufficient in extent for the stock kept, silage may be used to supplement them, and the animals thus be kept in good condition. Corn fodder or hay kept over until mid-summer is not so palatable or so good a supplement to pasture as silage.

QUALITIES NEEDED IN A SILO

While there are a great many different kinds of silos, made from different materials and by different methods, any silo, to be desirable must have certain qualities. The walls must be air-tight, smooth, water-tight, and strong. Silage is kept only by excluding the air from it. Unless one starts feeding as soon as the silo is filled, the upper four to eight inches molds and the silage is sealed in this way quite as effectively as fruit is sealed in a Mason jar. If there are holes in the wall, air will get through and some of the silage will spoil until enough mold has been formed to shut out the air.

The round silo is preferred to any other type, because there are no sharp corners into which the silage must be packed, or in which the air is likely to remain. Silage always settles several feet after being put in the silo. If the walls are not smooth it does not settle so well, but leaves pockets of air beneath the projections on the wall, which cause more or less silage to spoil.

Another requirement is that the walls be waterproof. The moisture in silage helps to make it pack, keeps out the air, and keeps the silage from heating too much. If the wall is not waterproof or is of such material that it absorbs a considerable amount of the moisure, the silage will not keep so well, and it is likely to be spoiled, especially next to the wall.

A silo must be so well built that it will stand erect and withstand the pressure of the silage inside. When a silo 30 or 40 feet high is full there is immense outward pressure on the wall, especially on the lower part.

Other desirable features, tho not so essential as those mentioned, are attractiveness and economical construction. A great deal more satisfaction will be derived from a silo that is attractive and pleasing to the eye, than from one not so built. There is considerable variation in the cost of different types of silos, but probably more in the different methods of building the same type. What most men want is a silo that will keep ensilage in a satisfactory way, that is neat and attractive, and that can be built at the lowest cost.

KIND OF SILO TO BUILD

It is not likely that men will ever agree on the kind of silo to build, any more than on the kind of house to build, or the breed of livestock to keep. There is room for much honest difference of opinion. Nearly all farmers who have silos are well satisfied with them; and most of them, if they were to build another, would build the same kind.

The Minnesota Agricultural Experiment Station has, on its main farm and substations, the following types of silos: one home-made wood-stave; one Puffer-Hubbard wood-panel; one patented wood-stave; one cement-stave; four 8-inch-wall hollow-clay-block; one 5-inch-wall hollow-clay-block; one solid-wall concrete. All of these have been in use two or more years, some of them much longer. Every one is keeping silage in good condition and giving satisfactory service. It would be hard to make any one who has seen these different types in use believe that there is only one good kind of silo.

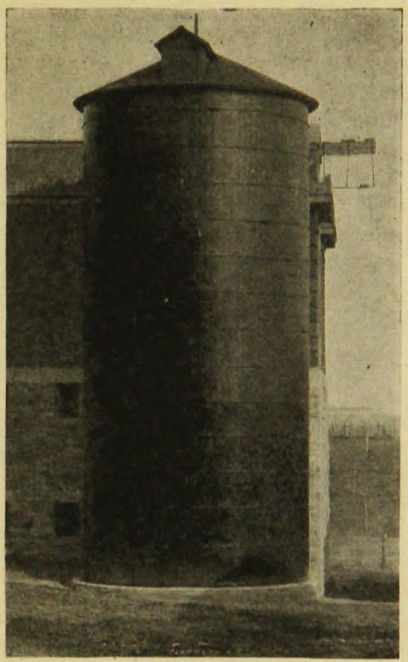

Fig. 1. Wood Stave Silo, Patented

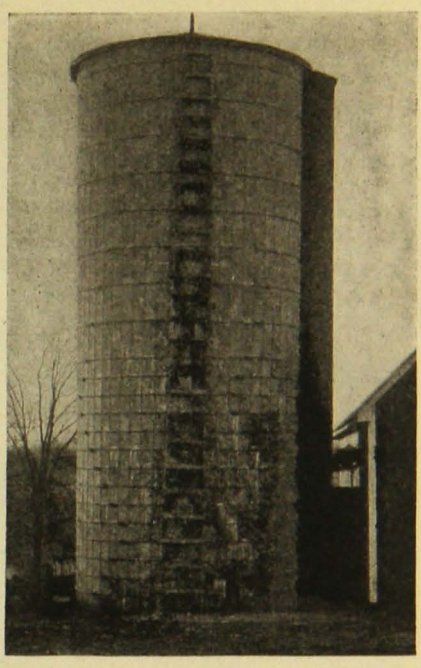

Fig. 2. Cement Stave Silo, Patented

Objections Weighed

Enthusiastic salesmen, who are trying to sell their particular silos, often distribute much misinformation regarding the merits and demerits of the different types. Statements are often made that a cement silo does not keep silage well; that the cement wall absorbs the moisture from the silage, and that the acid in the silage acts on the cement and gradually breaks down the wall. There is no basis for this statement. A concrete silo can be made waterproof just as well as any other. The walls must be properly constructed, with ample reinforcement, with enough cement to fill the spaces between the particles of sand and gravel, and the mixture must be put in wet enough to pack well; they must then be plastered and thoroly troweled on the inside or thoroly washed with cement wash or other waterproofing material. When this is done, the cement silo is waterproof, and silage will keep in it as well as in any other.

Because an occasional hollow-clay-block silo has been improperly built and insufficiently reinforced, and has cracked or given way entirely, the statement is often made by men desiring to sell other types of silos, that the hollow-clay-block silo is not satisfactory. No silo gives satisfaction unless it has been well built; and experience has shown that when hollow-clay-block silos are well built and properly reinforced they are entirely satisfactory.

The wooden silo is often objected to on the following grounds: (1) It is not permanent. This, of course, is true, tho two wood-stave silos at University Farm were in constant use, one for twenty and one for twenty-one years, and were still in good condition in 1917 when the main barn burned and the silos with it. (2) A wooden silo occasionally blowns down or blows away.

The same is true of wooden buildings of all kinds. If a wood-stave silo is well painted, well hooped, well anchored, and taken care of during the summer, when it is empty, it is not likely to be destroyed by wind. The wood-panel silo —that is, one having the boards put in horizontally—is not so likely to blow down as the wood-stave silo because lumber shrinks less lengthwise than sidewise and the hoops are consequently not so easily loosened.

It is much more important that a farmer build a silo than that he build any particular kind. Any common type, well constructed, will be found satisfactory. The most practical suggestion we can make is that each farmer build the type of silo that best pleases him; appearance, cost, availability of materials, and available mechanics considered.

METHODS OF PREVENTING FREEZING

It has been fully demonstrated that if silage is fed soon after it thaws out, freezing does not injure it. However, it is difficult and unpleasant to feed frozen silage, and the freezing certainly does it no good; so it is preferable to prevent such freezing if it can be done without adding unduly to the cost of the silo. A few years ago people were advocating the use of hollow-wall silos to prevent freezing. Experience, however, shows that the hollow-wall Gurler silo and the hollow-clay-block silo permit freezing very nearly, if not quite, as much as the solid-wall concrete or the wooden silo. All silos in Minnesota, under average weather conditions, fail to prevent freezing, that is, for about six weeks, during the coldest part of the winter.

Experience has proved that silage is more often frozen by the circulation of air over it than through the silo wall. If the door through which the silage is thrown out is left open, and there is any opening in the top of the silo, there will naturally be a circulation of air from outside through the open door, over the silage, and out at the top, because the silage is warm and gives off some heat. A perfectly tight top is therefore important. It is also important that the doors be kept closed; that is, as the silage is taken out, all the doors above the silage should be put back into place. The door through which the silage is thrown can quite easily be closed by a gunny-sack filled with chaff or cut corn stover, if it is not convenient to put the regular door back into place each time.

Another method of preventing freezing, is to cover the silage with chaff or loose hay, or with canvas. A canvas cover is the most convenient, as it can be thrown off more easily than the hay or chaff.

Another important factor in controlling the freezing of silage is that the silage be kept lower next to the wall than in the middle. Two wooden silos, with equal exposure, have been observed, on the same farm and at the same time, one with 3 feet of silage frozen on the wall, the other with none; the difference being caused solely by the method of taking out the silage. By using care during the most severe weather to keep the silage lower at the outside; by having the roof tight; by throwing a canvas over the silage; and by keeping all the doors closed, a large part of the freezing can be prevented, and this is a more satisfactory method than to try to construct frost-proof walls.

WHAT A SILO COSTS

The cost of a silo naturally varies. Prices range from $3 to $7 per ton capacity, for those holding 100 tons or more. The larger the silo, and especially the greater the diameter, the more cheaply it can be constructed. Home-made silos, where several can be built in one community and really handled as one job, can often be secured for from $2 to $3 per ton capacity.

The first cost, however, is not necessarily important. The important factor is the cost per year. To get the yearly cost, one must include interest on the investment, depreciation, and necessary repairs. It is plain that depreciation will be much less on a permanent silo, such as one well built of concrete or brick, than on a wooden one. For example: If a temporary silo costs $300, and lasts sixteen years, the depreciation will be 6 per cent and the interest 6 per cent, making the annual cost $36 per year. If a permanent silo costs $450 and lasts fifty years, the depreciation would amount to 2 per cent. This, added to the interest, would make 8 per cent, making the annual cost $36 per year.

SIZE OF SILO TO BUILD

A common mistake is building silos too large in diameter. A cow or steer will consume from 30 to 40 pounds of silage per day. The average feeding-period in Minnesota is about 200 days. If an animal is fed 40 pounds of silage per day for 200 days it will consume 4 tons of silage. Bearing these figures in mind, it is easy to adjust the capacity to the size of the herd kept. It is better to build a silo reasonably high than to try to get the desired capacity by building it large in diameter. The same amount of storage capacity can be secured more cheaply in a silo of large diameter, but loss results from inability to keep the silage fresh while feeding.

TABLE I. APPROXIMATE CAPACITY OF ROUND SILOS
(After King)

Height of silo	Mean weight of silage per cu. ft.	Diameter in feet						
		8	10	12	14	16	18	20
Feet	Pounds	Tons	Tons	Tons	Tons	Tons	Tons	Tons
20	33.3	17	20	38	51	67	85	105
22	34.6	19	30	43	59	77	97	120
24	35.9	22	34	49	67	86	110	136
26	37.2	24	38	55	75	97	123	152
28	38.4	27	42	61	83	109	137	169
30	39.6	30	47	67	91	119	151	187
32	40.7	33	51	74	100	131	166	205
34	41.8	36	56	80	109	143	181	224
36	42.8	39	61	87	118	155	196	243
38	43.8	41	65	94	128	167	212	262
40	44.8	45	70	101	138	180	228	282
42	45.7	48	75	109	148	193	244	301
44	46.7	51	80	116	159	207	261	323
46	47.3	54	85	123	168	219	277	341
48	48.0	58	90	130	177	231	293	361
50	48.8	62	95	138	188	245	310	383

Silage is always fed from the top of the silo; and if the top is left untouched for several days, the silage will spoil. Spoiling, of course, is much more rapid in warm weather than in cold. The silo should not be so large in diameter but that an inch and a half or two inches can be fed from the top each day. A silo 10 feet in diameter has about 78 square feet of floor space; so that it would have at all times that amount of surface exposed at the top. An inch and a half taken off the top of a 10-foot silo would amount to 10 cubic feet. A cubic foot of silage weighs about 40 pounds; so the least number of cattle that one could feed from a silo 10 feet in diameter, without waste, would be ten head, fed at the rate of 40 pounds per day.

A silo 30 feet deep is 360 inches deep, and if silage is used at the rate of 2 inches per day, it would furnish feed for 180 days.

TABLE II. WEIGHT OF SILAGE PER INCH OF DEPTH

Diameter of silo	Area of silage	Depth 1 inch*	Depth 2 inches*	Depth 3 inches*
Feet	Square feet	Pounds	Pounds	Pounds
12	113	376	752	1,128
13	133	440	880	1,320
14	154	512	1,024	1,536
15	177	590	1,180	1,770
16	201	670	1,340	2,010
17	227	756	1,512	2,268
18	254	846	1,692	2,538
20	314	1,046	2,092	3,138

* Forty pounds per cubic foot.

Wise to Build Reasonably High

It is perfectly safe in almost any location to build a silo from 35 to 40 feet high or more. Cement or brick silos may safely be built 50 feet high. It is the part of wisdom to build reasonably high, and only large enough in diameter to give the capacity needed for feeding. If silage is to be used in summer, it will be necessary to figure on feeding at least 3 inches off the surface each day. At this rate a 10-foot silo will supply ample silage for 20 head of stock.

TABLE III. CATTLE FED PER INCH OF DEPTH

Diameter of silo	When fed 30 pounds each per day			When fed 40 pounds each per day		
	1 inch	2 inches	3 inches	1 inch	2 inches	3 inches
Feet	Cattle	Cattle	Cattle	Cattle	Cattle	Cattle
12	12.5	25.0	37.6	9.4	18.8	28.2
13	14.6	29.3	44.0	11.0	22.0	33.0
14	17.0	34.1	51.2	12.8	25.6	38.4
15	19.6	39.3	59.0	14.7	29.5	44.2
16	22.3	44.6	67.0	16.7	33.5	50.2
17	25.2	50.4	75.6	18.9	37.8	56.7
18	28.2	56.4	84.6	21.1	42.3	63.4
20	34.8	69.7	104.6	26.1	52.3	78.4

It is more practicable on most farms to have two silos 12 feet in diameter than to have one silo 16 or 18 feet in diameter, because those smaller in diameter allow more economical feeding.

The following sizes are suggested: For 10 cows, 10 feet in diameter; for 15 cows, 12 feet; for 20 cows, 14 feet; for 30 cows, 16 feet; silos to be made from 30 to 50 feet high.

PATENTED OR HOME-MADE SILO—WHICH?

Most of the silos in the country are patented. These are more common than some of the home-made silos simply because some one is making an effort to induce people to buy them. The difference between home-made and patented silos should be thoroly understood. A patented silo or any silo that is sold through a regular selling agency must sell for enough more than it costs to

pay the expense of selling and leave a profit. The expense of selling a silo often amounts to one hundred dollars or more. For this extra hundred dollars the farmer gets in return some information that he did not before have about silos, and he probably is induced to build one a little sooner than he otherwise would have built—which is often a good thing. He is relieved of the responsibility or trouble of looking after the details of the construction, and in many cases this extra service is worth all it costs him.

In other cases a man does not need to hire this outside education or mechanical ability, and can much more cheaply look after the details of building his own silo than contribute to the revenue of some patentee. By putting up a home-made silo, especially if suitable mechanics are available, a better silo usually is obtained for the same amount of money than by buying a patented one.

WHERE TO PUT THE SILO

The first consideration in locating the silo is to have it convenient; that is, as near as possible to the place where the bulk of the silage will be fed.

Another matter of importance is to have it on the least exposed side of the barn. A silo will freeze more readily on the north side of a barn than in the more sheltered position on the south side. However, many silos are built on the north side, and give good satisfaction; and it is better to have the silo conveniently located in another place than to have it inconveniently located on the south side. Where stock is kept in a basement barn, a silo can often be constructed on the upper side of the barn, and thus 10 or more feet of the lower part of the silo be built below ground, where freezing will be very slight. Under such conditions, the silo would be placed on the high side of the barn, regardless of direction.

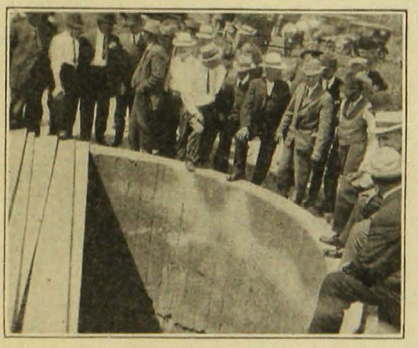

Fig 3 Cement Foundation for Silo on Farm of Anton Nordberg, Starbuck, Minn.

Fig. 4. Home-Made Cement Blocks Used in Construction of Silo on A. L. Brevig's Farm.

FOUNDATION IS IMPORTANT

The foundation is the first part of the silo to construct, and even if a patented silo is built the owner usually furnishes the foundation. The foundation is always important, but it is exceedingly important if a permanent type of silo is to be constructed; because if the foundation gives the wall is almost sure to crack.

Where drainage conditions are favorable—that is, where the soil is dry enough—the foundation should extend at least 5 feet below the surface of the

ground. There should be a base 2 feet wide and at least 1 foot deep at the bottom, and above this a wall 8 inches or more thick.

Concrete is the most common material used. The foundation should rise from 6 to 12 inches above the level of the ground. A few people are now suggesting that the foundations for all types of silos extend 3 feet above the ground, to prevent the silo proper from injury by livestock or machinery. There is no loss in extending the foundation a few feet below the surface of the ground, because this space may be used for storage of silage. Silage can easily be thrown out of a pit four or five feet deep. It is advisable to reinforce quite strongly the foundation, especially if it extends 8 inches or more above above the surface of the ground. If one plans on using this part of the silo for storage, the expense is not out of proportion to the additional capacity secured.

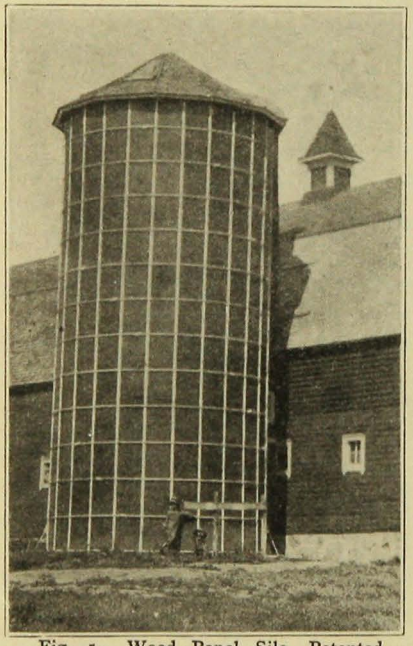

Fig. 5. Wood Panel Silo, Patented

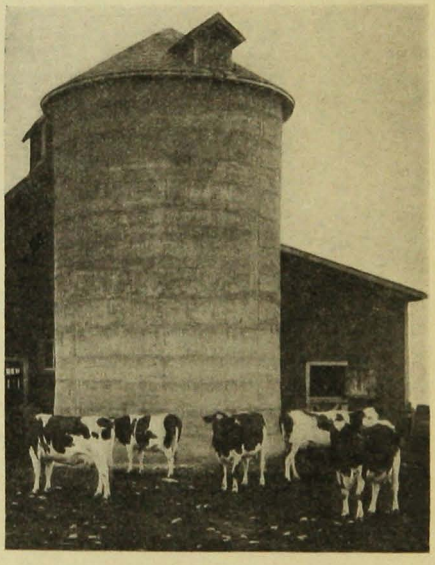

Fig. 6. Home-Made Solid-Wall Concrete Silo, Crow Wing County

HOME-MADE SILOS THAT GIVE SATISFACTION

Solid-Wall Concrete Silo Has Good Points

In communities where sand and gravel are available, and where a man can be secured who understands the use of concrete and the necessary reinforcement for a concrete silo, the solid-wall concrete silo is a type well worth considering. Forms for the construction of these may be purchased, or, if desired, may be made at home. There is no patent on these silos; it is just a matter of getting material and mechanics together and doing the work. There is considerable risk in building a concrete silo, unless mechanics are available who understand the work thoroly. Building a silo is not at all a complicated matter, but there are certain things that must be done carefully and accurately. Forms must be well made; sand and gravel must be clean; there must be the proper proportions of cement, sand, and gravel; all must be properly mixed and placed, and proper reinforcement must be used. A man without experience is very likely to fail to do something that should be done and results are then likely to be unsatisfactory.

Directions for building a concrete silo are to be found in Agricultural Extension Bulletin No. 41, a copy of which may be had by writing to the Office of Publications, University Farm, St. Paul, Minn. Cement companies also send out, free of charge, very full and reliable information on the construction of concrete silos. Farmers' Bulletin No. 589, "Home-Made Silos," may be secured by writing to the United States Dept. of Agr., Washington, D. C.

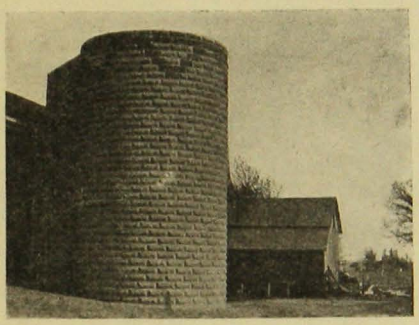

Fig. 7. Concrete Block Silo

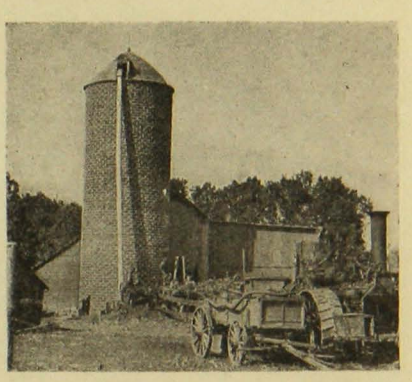

Fig. 8. Home-Made Hollow-Clay-Block Silo

Concrete Block Silo May Be Built on Farm

Concrete-block silos can likewise be built on the farm. One man or several men may purchase the molds for making the blocks, and make them at home. These silos, when the work is well done, are thoroly satisfactory in every way.

Concrete silos are often built by contractors who have their own forms, molds, mixing machinery, etc.; or the equipment may be purchased coöperatively.

Hollow-Clay-Block Silo Not Difficult to Build

The hollow-clay-block silo can be built at home. The clay blocks can be bought from brick and tile factories; the reinforcement rods can be bought at any hardware store, and the lime and cement are as easily obtained. These silos are not at all difficult to construct. Any man who has seen one built, understands how to reinforce them, and has had experience in laying brick, can do very satisfactory work. Hollow-clay-block silos, when well constructed, are presumably permanent. Altho these are often built without being plastered, they are much more satisfactory when well plastered with a coat of rich cement plaster. This makes the wall perfectly smooth, and water- and air-tight. Several brick companies build these silos on contract.

For further details regarding the construction of hollow-clay-block silos write to the Office of Publications, University Farm, St. Paul, Minn.

Plans Needed for Wood-Stave Silos

Wood-stave silos are not often built except when a patented silo or one offered by some selling agency is purchased. However, there is nothing to prevent one from buying the material and building his own silo; and if a carpenter with experience is available there is no difficulty in building just as good a stave silo as is commonly offered by the selling agencies; the only difference

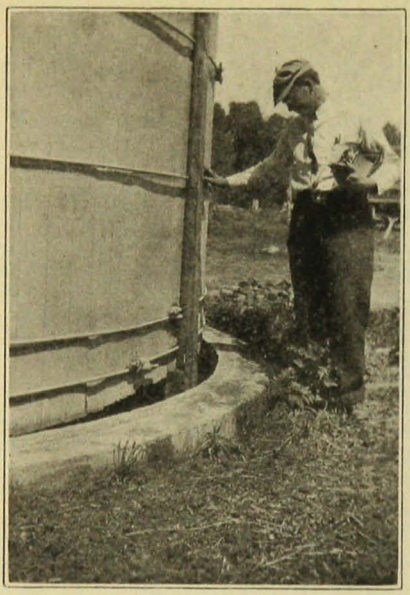

Fig. 9. Stave Silo Not Properly Anchored. It was moved off its foundation.

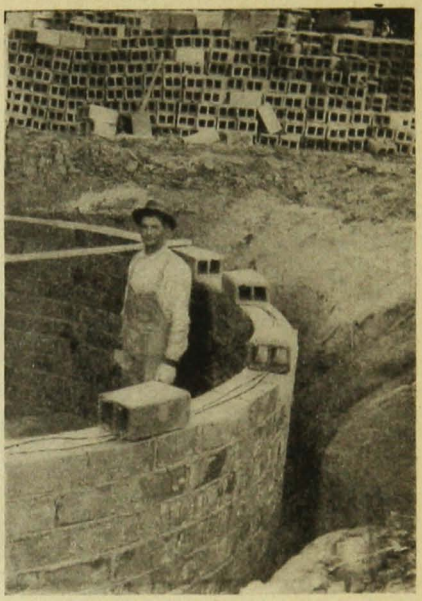

Fig. 10. Building a Hollow-Clay-Block Silo on Mr. Kronlokken's Farm, Renville

being that the farmer must do, or get someone else to do, the planning that the company does for him when he buys a ready-made one.

For the walls of a stave silo, 14x36 feet in size, only about 3,500 feet of 2x6 are needed. The 2x6 should be surfaced on both sides, and jointed on both edges. It is not at all necessary that they be tongued and grooved, or even beveled. Full-length pieces are desirable, but not necessary. Any quality or length of material wanted can usually be obtained from any lumber dealer.

Kind of wood to use.—Cypress is the most durable wood for the silo, but is expensive. Washington fir is most commonly used. It can be obtained in long lengths, is usually free from knots and sap, and is very durable. White pine is next best; in fact, a good quality of white pine is very desirable. It is not easy to get it in long lengths, but silo staves may be spliced without serious detriment to the structure. Hemlock, tamarack, and Norway pine are used, but are not nearly so good as the kinds of wood mentioned above.

A stave silo, or any silo built of wood, should be thoroly oiled and painted on the outside, and oiled with boiled linseed oil on the inside. Round mild steel rods, from ½ to ¾ of an inch in diameter, should be used for hoops. These can be purchased through any local hardware dealer. It is better to have an extra hoop or two than too few. For a 14- or 16-foot silo, the hoops should be not more than from 24 to 30 inches apart below the middle of the silo, and the first hoop must be placed very near the bottom.

For silos 14 feet in diameter the lower two thirds of the hoops should be of ⅝-inch steel and the upper one third of ½-inch steel. For silos larger than 14 feet in diameter, hoops for the lower third should be ¾ inch; for the middle third, ⅝ inch; and for the top third, ½ inch in diameter.

The following, from Minnesota Farmers' Institute Annual No. 24, shows how five Meeker County farmers secured stave silos very cheaply.

FARMERS MAY COÖPERATE IN BUILDING

By Charles Nelson, Litchfield, Minn.

"Five farmers in the neighborhood of Litchfield, coöperated and purchased building material in large quantities. They united and aided each other in erecting a stave silo on each of their farms. The following is the cost of material and labor in building one of these on the farm of Gilbert Jorgenson, who furnished these figures. The silo is 36 feet in height and 16 feet in diameter:

116 pieces 2x6, 30 ft., Washington fir, at $32 per M.....	$111.36
26 pieces 1x12, 12 ft.....	10.42
Ripping boards, corner to corner, for roof.....	0.50
Hoops, 10 3/16 in., 54 ft.....	25.00
4 pieces 2x4, 18 ft. rafters.....	1.34
Other lumber	7.00
Cement for foundation	15.00
Labor in cement	15.00
Carpentry, 10½ days, at $2.25.....	23.25
Common labor, excavation and raising.....	7.11
Paint	6.80
Labor of painting (three coats).....	5.00
Hardware	1.00
Total.....	$228.78

"This is the actual cost of the silo complete. The real cash outlay did not exceed $200, as Mr. Jorgenson and boys did most of the carpentry, painting, and common labor themselves. Staging was either returned or used on the farm, so no account is made of it, except labor."

These silos were built several years ago when materials and labor were much cheaper than at present. However, coöperation in buying materials and in building usually offers an opportunity for saving.

For further information regarding the construction of stave silos write to the United States Dept. of Agr., Washington, D. C., for Farmers' Bulletin No. 589.

PLASTERED SILO A PRACTICAL KIND

The Gurler or plastered silo is a very practical type where timber is cheap and plentiful. It can be constructed entirely of cheap grades of lumber, something that can often be obtained from the home wood-lot, and any carpenter should be able to build such a silo. It is built very much like a frame building. A foundation, the same as for any silo, is made, with a sill of 2x4's cut in 2-foot lengths, imbedded in the top. This should be anchored to the foundation by heavy bolts. Two-by-four studding is then set up and toe-nailed to this sill. The studding may be placed any distance apart, up to 2 feet. Some builders place the studding just one foot apart from center to center on the outside. This permits boarding up the outside with 12-inch boards, running up and down. The cracks are covered with battens. The inside is boarded up with half-inch rough lumber. Common fence-boards may be ripped length-wise to make the half-inch lumber. These boards are bent around on the inside and nailed securely to the studding.

A continuous door, or individual doors, may be built as desired. The individual type is preferable. The door openings should be about 2 feet wide and

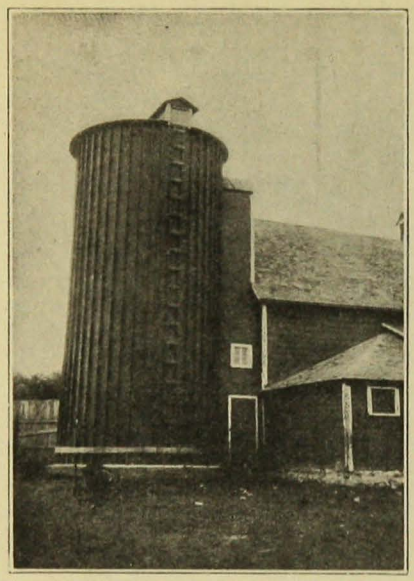

Fig. 11. Gurler Silo on Lee Brothers' Farm, Villard, Minn.

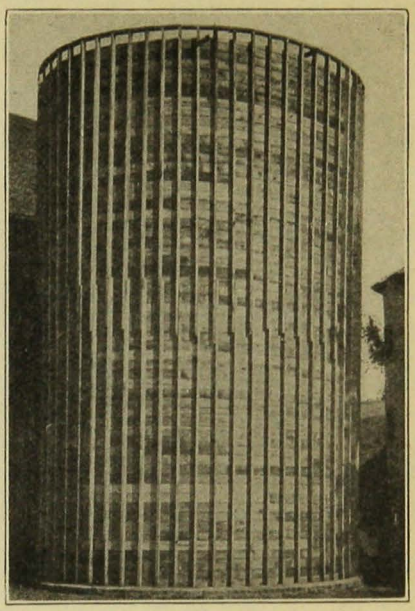

Fig. 12. Manner of Lapping Studding in Building a Gurler Silo.

30 inches high. From 2½ to 3½ feet of space is boarded solid between doors. On each side of the openings a 4x4 is placed. These are most easily made by spiking two 2x4's together. There is an advantage in placing these two 2x4's on either side of the door, with the two 2-inch edges toward the door opening, rather than the 4-inch side. This arrangement leaves a 4-inch flat surface on the inside, on which the door and the inside sheeting and plaster can lap. Care must be used to have the doors fit, so as to come exactly even with the plastering on the inside, so there will be no unevenness in the wall. The doors are easily made of two thicknesses of 1-inch lumber, crossed and nailed together, similar to an ordinary barn door. The strength of the Gurler silo comes from the half-inch sheeting used on the inside; consequently, in putting this on, pains should be taken to break joints.

The silo may be built of any desired height simply by lapping the studding, as indicated in Figure 12. After the silo is sheeted up, it is lathed with ordinary lathing. In lathing, it is also desirable to break joints. The inside is then plastered with a rich sement plaster, made by mixing two parts of sharp, screened sand and one of cement. The last coat should be very thoroly troweled, so it will be perfectly smooth. After the plaster is dry it should be gone over with a cement wash made by mixing pure cement and water to about the consistency of cream. This should be applied with a whitewash brush.

Additional strength may be given by wrapping heavy smooth fence wire around the silo outside of the studding at several places, especially near the bottom. By using several strands of wire for each band, and by twisting these together between the studding at several places, the wire can be very effectively tightened.

The most satisfactory outside sheeting for these silos is 12-inch boards running up and down, as it is hardly practicable to bend any kind of lumber sufficiently short to sheath the outside of a small round building. If the studding is set more than 12 inches apart, circular bands can easily be made around the silo, every 3 to 5 feet, by using 4 to 6 thicknesses of the half-inch lumber; taking care, of course, to break joints, and to miss the door openings. These bands of half-inch lumber give the silo additional strength, beside providing a place for nailing on the sheathing. If these bands are put on it is not necessary to put wire bands around the outside.

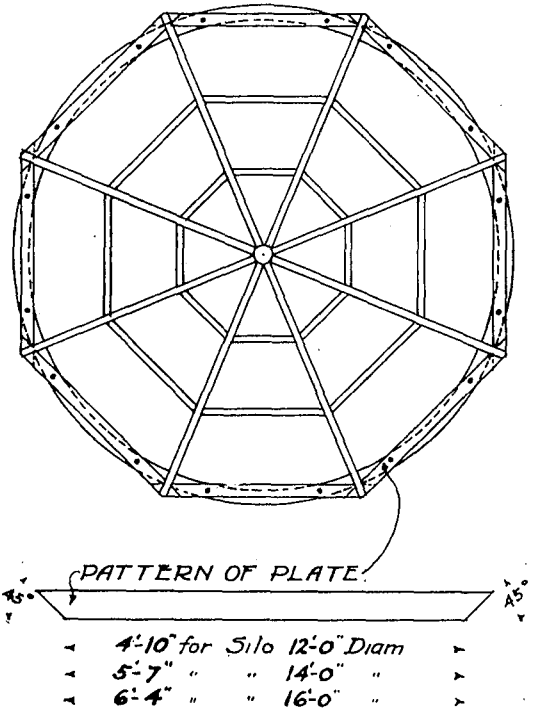

Fig. 13. Method of Laying Out Octagonal Roof for Silo

These silos should be thoroly anchored from three or four directions, by strong wire cables. The plate is put on top of the studding the same as the sill; that is, 2x4's are cut in 2-foot lengths and spiked on top of the studding.

Roof

The roof may be made by extending from eight to twelve rafters from the plate to the center. Eight of these rafters will suffice, with circular cross-pieces nailed between, upon which to nail the roofing boards. The roof boards are most conveniently made by ripping cornerwise boards of the proper length to reach from the peak to the eaves, and placing the points of these triangular boards at the peak. Such a roof may be shingled, or, more easily and at less expense, covered with three- or four-ply prepared roofing. If one does not care to go to the bother of making a circular roof, an octagonal roof is easily constructed by spiking on a double plate, using, for a 12-foot silo eight pieces 2x4, 4 feet, 10 inches long; for a 14-foot silo, eight pieces 2x4, 5 feet, 7 inches

long; and for a silo 16 feet in diameter the eight pieces for the plate should be cut 6 feet, 4 inches long. See Figure 13. Eight rafters would then be extended to the peak, one from each of the eight corners of this plate.

A dormer window should be provided in the roof for putting in the silage. An octagonal roof does not look so well as a circular roof, but is easier to build. The roof boards may be put on horizontally, thus saving the ripping necessary for a circular roof. It is also more easily shingled or covered with roofing.

For further information regarding the construction of the Gurler silo, write to thte United States Dept. of Agr., Washington, D. C., for Farmers' Bulletin No. 589.

Where Crib Silos May Be Built

In sections where lumber is plentiful, the crib silo is a practical type. This is built of pieces of 2x4 or 2x6—2x4's are strong enough—cut 2, 3, or 4 feet long, and laid up in the same manner as in building an elevator, only by using short pieces the silo is made practically round. These pieces are laid flatwise, one on top of the other, and spiked together. Each course laps over the course below in such a way as to make a good joint and give the silo strength. Such a silo can be built without hoops for reinforcing. More timber is required than for a stave silo, but a poorer and cheaper grade of lumber can be satisfactorily used. It is a very simple form to build but is not very durable because the joints between the pieces being horizontal moisture does not run out readily, and the timber rots more quickly than in a stave silo.

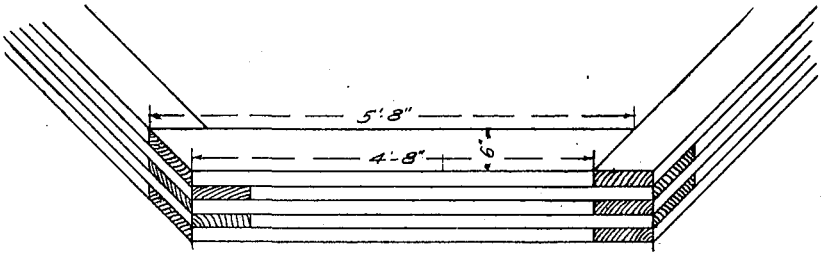

Fig. 14. Pattern for Cutting Material for Eight-Sided Crib Silo 14 Feet in Diameter

Pit Silos Are Cheapest

A type that is becoming quite common, in the semi-arid regions especially, is the pit silo. This consists of a hole in the ground, the sides of which are plastered with cement mortar, as a cistern is. Where there is no ground-moisture to give trouble, this type of silo is very satisfactory. This is the cheapest type. The greatest objection is the labor of getting the silage out of the pit, altho with a proper derrick this is not so serious as it first seems. Most Minnesota farmers, we believe, prefer to elevate silage with an engine, when they are filling the silo, to lifting it out of the pit, a small amount at a time, as needed.

To dig these pit silos, a place is leveled off on the ground; then a circle is made of the desired diameter. Six or eight inches outside of this circle another is made, and the trench thus marked out is dug out with a narrow spade to a depth of three or four feet. The dirt is left in the center, and the trench is then filled with concrete. This furnishes a collar, or shoulder, for the top of the silo. It is desirable to extend this foundation, or collar, a foot, and sometimes two feet, above the level of the ground, to prevent surface-water from running in. If dirt is then graded in against the outside of this wall, the thin plastering below the concrete collar will be protected from freezing, which

may prevent its cracking. After the concrete has had a chance to set, the dirt on the inside is dug out. As the silo is dug down below the collar, the wall is plastered with rich concrete mortar, made by mixing one part cement and two parts screened sand. Two or three coats of plastering are usually applied. Only a comparatively small amount of cement and no reinforcement is necessary in building such a silo, consequently the cost, outside of the labor, is very small. We know of but one such silo in Minnesota. This is on the farm of C. F. Kirk, at Morris, Minn.

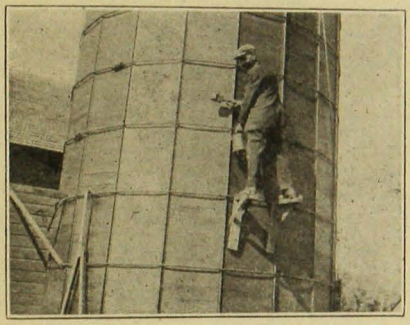

Fig. 15. Painting Without Scaffolding.

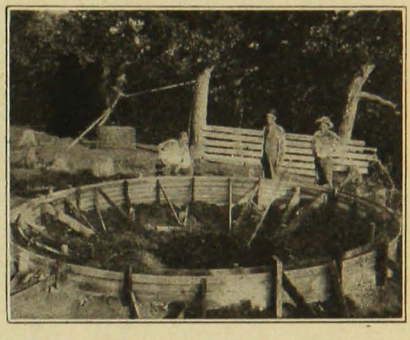

Fig. 16. Starting the Second Pit Silo on C. F. Kirk's Farm, Morris, Minn.

At any place where the water does not come within 20 or 30 feet of the surface, one of these silos can be used with a fair degree of satisfaction. They will probably never be of great importance in Minnesota, altho they are giving good satisfaction in western South Dakota, Kansas, and Nebraska.

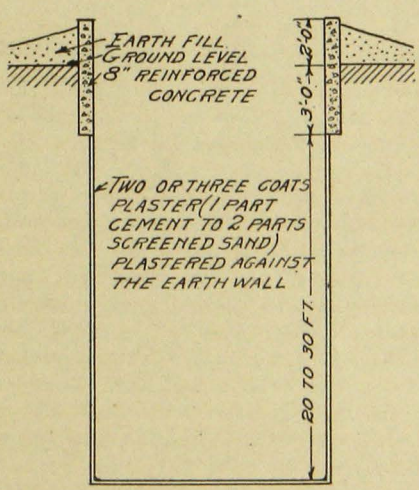

Fig. 17. Pit Silo.

Old Silos May Be Plastered

Old wood-stave, panel, or crib silos, may often be made to last several years longer by straightening up and lathing and plastering on the inside. A

good coat of plaster is not expensive, and it makes the silo air-tight and water-proof and protects the woodwork.

MONEY SAVED BY COÖPERATION

The larger the number of silos that one man or group of men can build, the more cheaply can they be constructed. A group of farmers in Minnesota, who wanted twenty or more silos, and who finally decided on a patented silo commonly sold in the community, were able to save more than $100 on each silo. This was due to the fact that the agent or dealer could afford to sell twenty silos on a much smaller margin than he could sell one.

Several silos of any of the types mentioned can be more cheaply built than only one. This is especially true of the cement silos, where either forms or molds for making the blocks must be used. A set of forms can just as well serve for ten or more silos as for one, and materials can always be purchased more cheaply in large quantities than in small lots. A silo-building crew can put up about 8 solid-wall concrete silos in a season. If that number are to be built in one locality, a contractor can usually be induced to buy forms and mixing machinery to build them.

FARMERS MAY COÖPERATE IN FILLING SILOS

An expensive part of the production of silage is the cutter and engine for filling. This is an especially heavy expense where there is only one silo in the community, and the whole outfit must be purchased by one man. One good-sized cutter may be used to fill several silos in a season, and where practicable it is advisable for several farmers to coöperate in its purchase and use. If several in a community have silos to fill, the man who does the threshing can usually be prevailed upon to postpone threshing long enough to use his engine and crew for silage-cutting.

SILAGE MAY BE STACKED WITH SUCCESS

In some sections green corn is being stacked out of doors quite successfully, and fed as silage. The plan is carried out about as follows:

A level place is made on the ground, or preferably hollowed out slightly in the center. The stack of green corn is started about the same as a stack of grain, except that an effort is made to keep the center lower than the outside. The stacks should be at least 14 feet in diameter, and preferably 18 feet. Pack the outside tier of bundles just as closely together as possible. It is sometimes necessary to remove the ears from the outside tier and throw them to the center, so that the outer bundles will pack more closely. The higher these stacks are built, the better. They should be just as high as one can conveniently raise the bundles. The top of the stack is left flat and covered with straw or hay. If the stack is not from 12 to 14 feet high when completed, there is some advantage in placing planks crosswise of the stack, and piling on a few loads of stone to aid in the settling. The more completely the stack settles, the more thoroly air is excluded from the corn.

The outer 12 to 20 inches of the stacks will spoil. This portion is cut off, usually with a hay-knife, and the entire center of the stack used for silage.

A large number of farmers in northwestern Minnesota have used this method of putting up silage with a considerable degree of satisfaction. Of course, there is more waste than in a good silo. It is not so convenient to feed corn from the stack as from the silo, and the silage is usually not so good in quality; but corn can be stored in this way, and it will prove a fairly good substitute where it is impractical to build a regular silo.